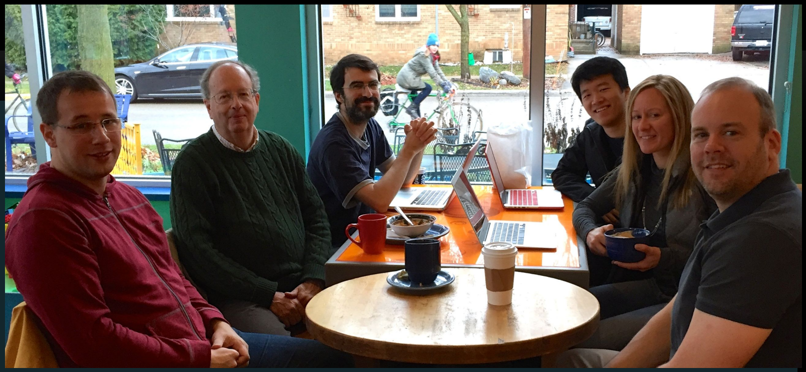
WFIRST Prep Science: Colors of Planets and Background Sources



WPS Team Members

PI Margaret Turnbull (SETI)

Co-I Tristan L'Ecuyer (UW Atmospheric Sciences)

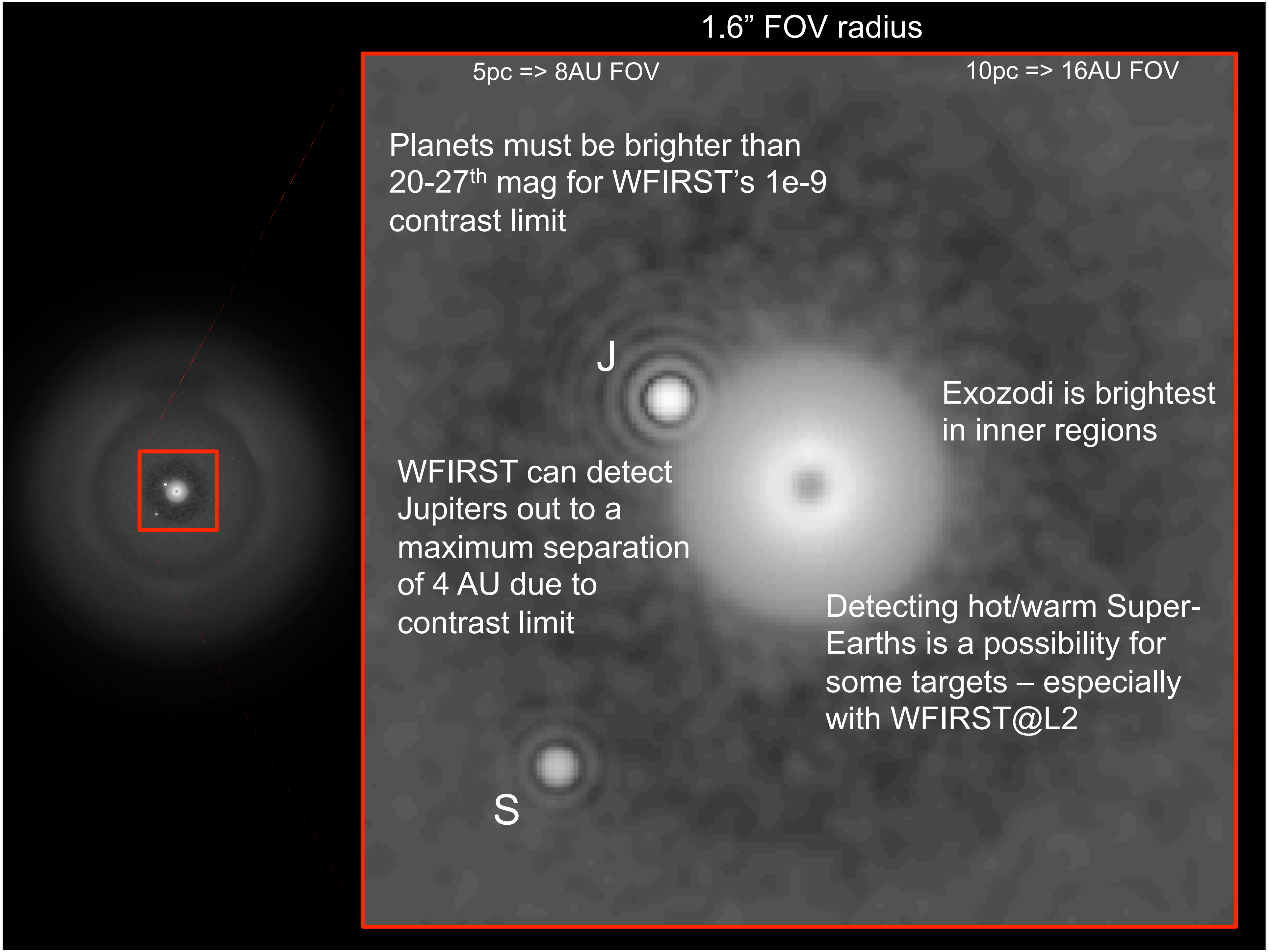
Co-I Renyu Hu (JPL)

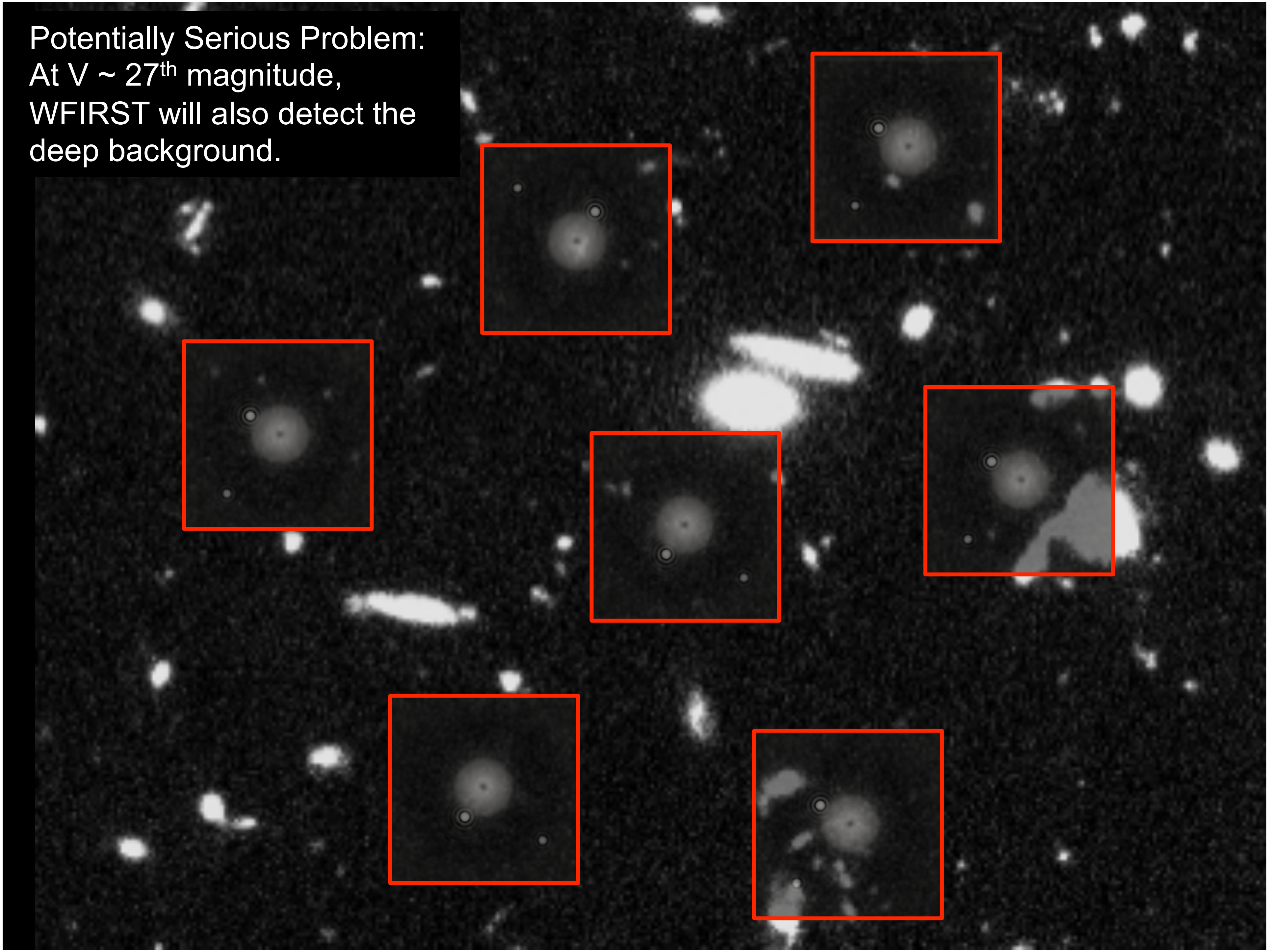
Collaborator Jay Gallagher (UW Astronomy)

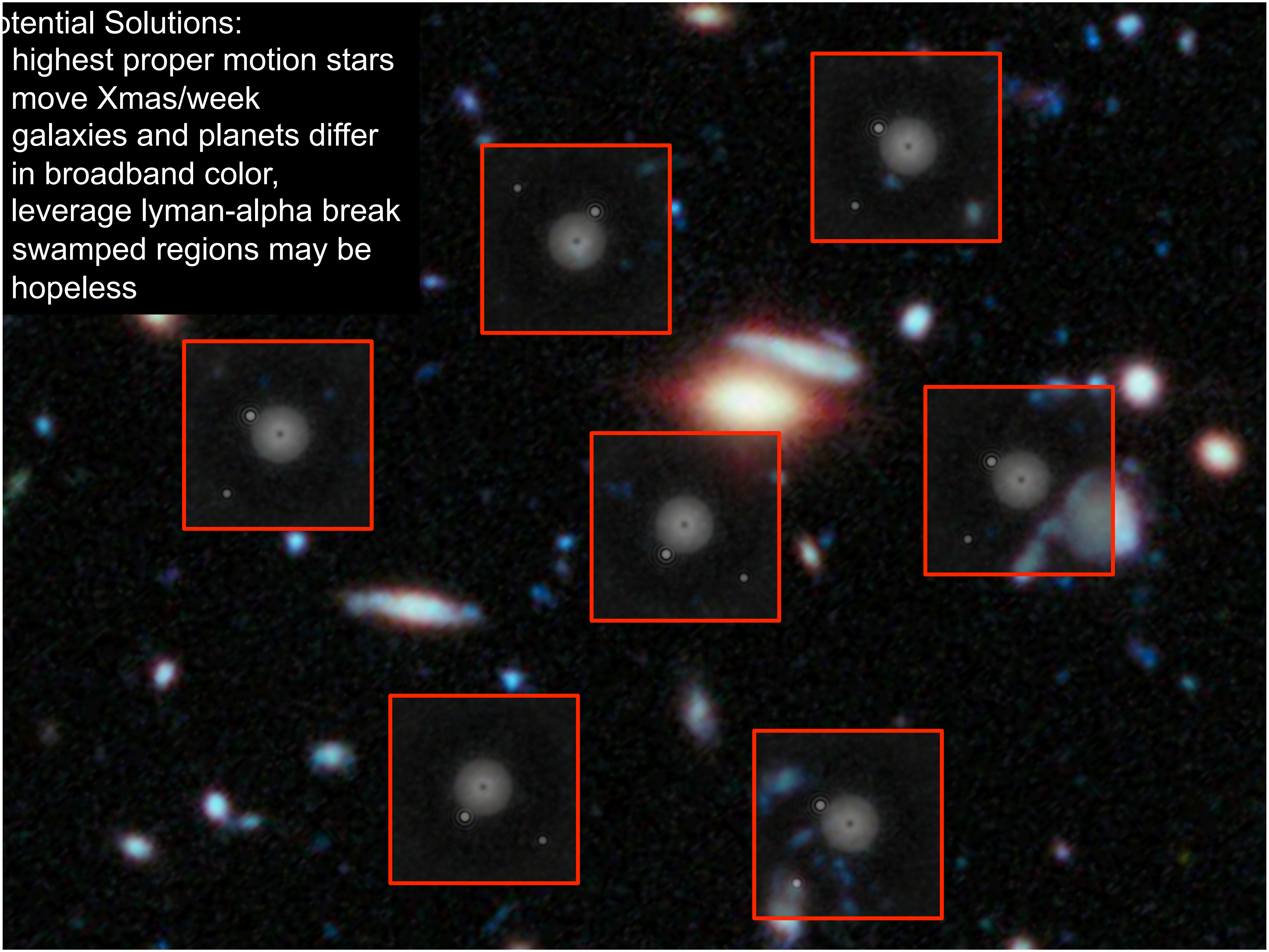
Postdoc Aronne Merrelli (UW SSEC)

Senior Scientist Ralf Kotulla (UW Astronomy)

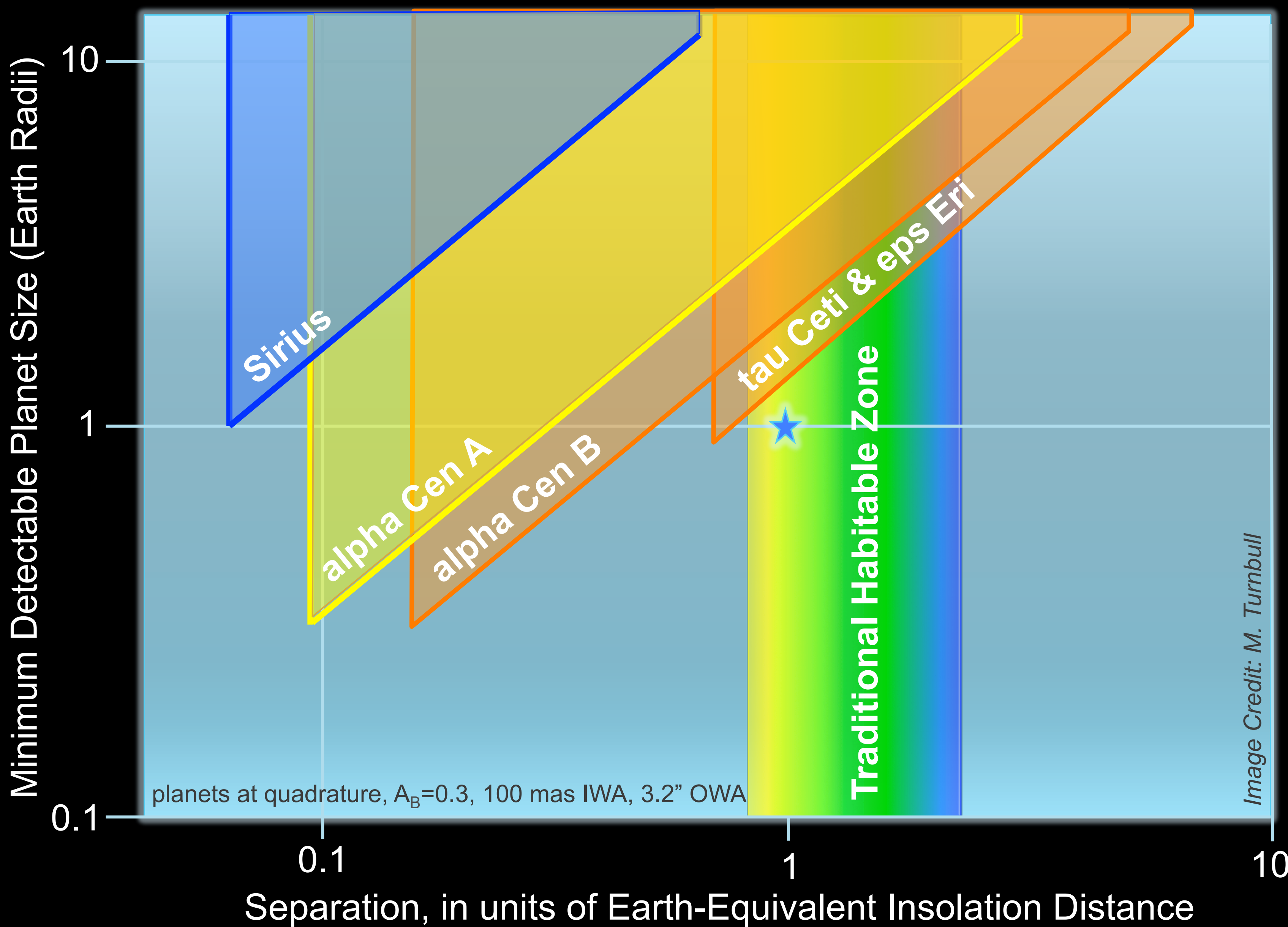
Undergraduate Guangwei Fu (UW Astronomy)


1.6” FOV radius
5pc => 8AU FOV
10pc => 16AU FOV
Planets must be brighter than 20-27th mag for WFIRST’s 1e-9 contrast limit
J
Exozodi is brightest in inner regions
WFIRST can detect Jupiters out to a maximum separation of 4 AU due to contrast limit
Detecting hot/warm Super-Earths is a possibility for some targets – especially with WFIRST@L2
S


Potentially Serious Problem:
At V ~ 27th magnitude,
WFIRST will also detect the
deep background.


tential Solutions:
highest proper motion stars move Xmas/week
galaxies and planets differ in broadband color, leverage lyman-alpha break
swamped regions may be hopeless

Planets of Interest: WFIRST Detection Space



WFIRST Prep Science:
Colors of Planets and Background Sources

GOAL

1. Determine the WFIRST broadband colors for potentially detectable planets:

   -> include Venus, Earths/super-Earths and sub-Neptunes through cold giants

   -> assess capability of WFIRST to distinguishing planet types in color-color-magnitude space, especially for "discovery" targets where characterization may not always be possible

WFIRST Prep Science: Colors of Planets and Background Sources

GOAL

2. Publish a library of spectra for planets of interest to WFIRST:

-> include Solar System planets, Earths/super-Earths and sub-Neptunes through cold giants, orbiting stars of various spectral types

-> include Earth/super-Earth spectra of various Earth-”like” planets: ancient Earths, Dunes, waterworlds, ice worlds

-> include variety of phase angles and inclinations

3. Create an online tool for generating spectra and colors for wide variety of objects and bandpasses

WFIRST Prep Science: Colors of Planets and Background Sources

GOAL

4. Determine the prevalence and WFIRST broadband colors of background sources

-> assess capability of WFIRST to distinguishing planets from background in color-color-magnitude space

-> assess “background threat” for high priority exoplanet imaging targets: consider proper motion

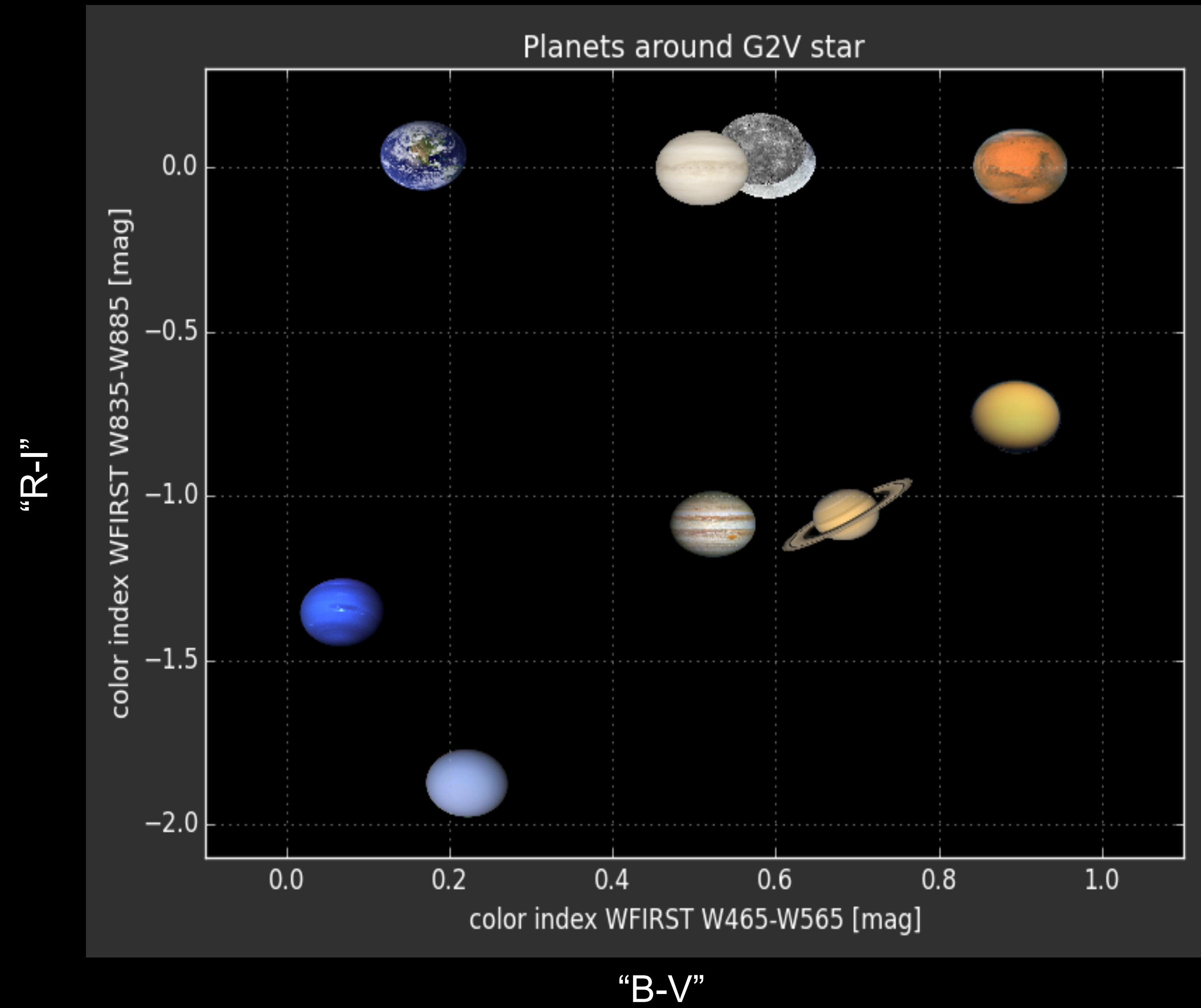
-> suggest plan for mitigating that threat including possibility of alternative bandpasses, advance observations

-> assess scattered light threat due to bright companions

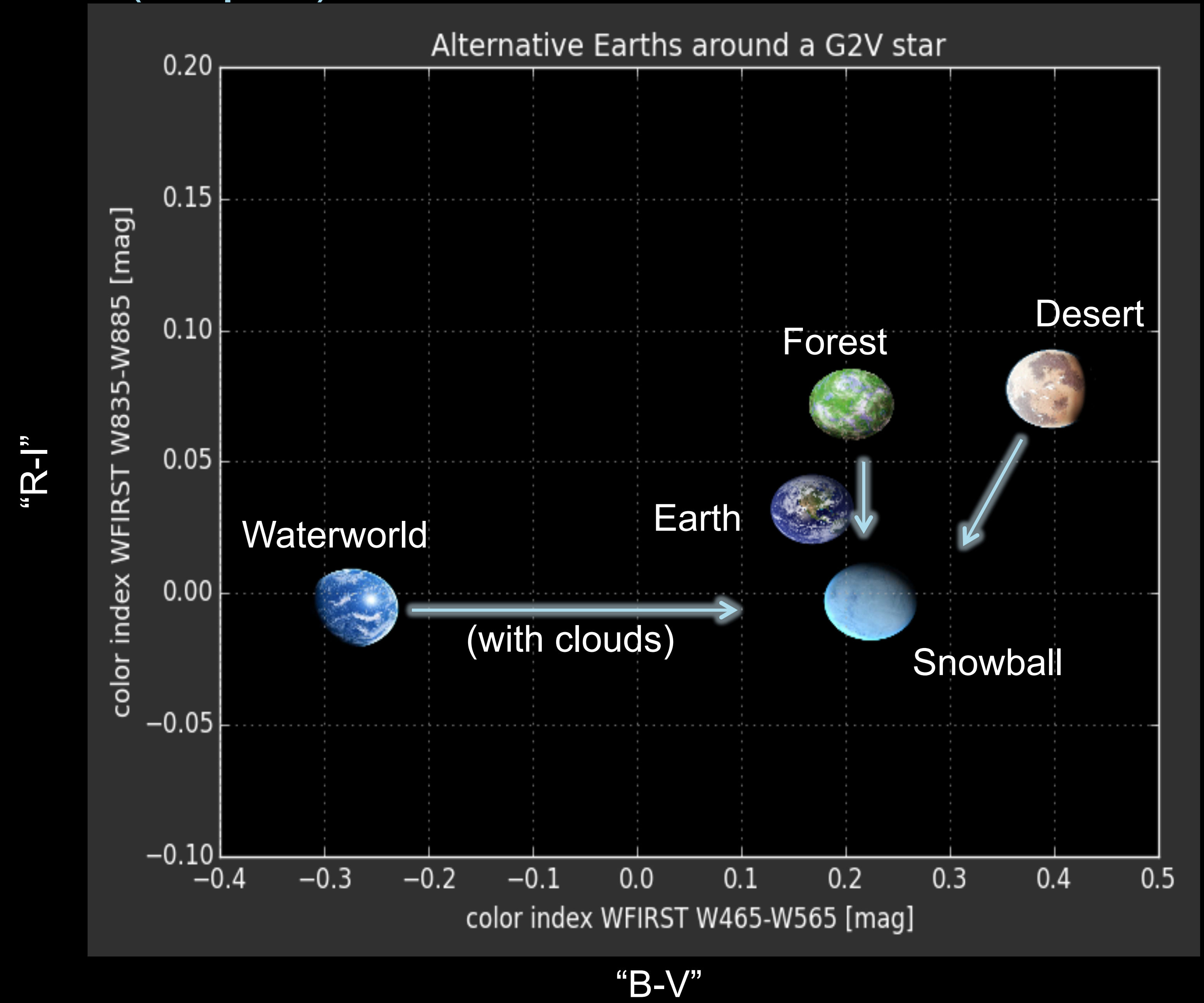
Planets Around the Sun: WFIRST Bands

λ_0 (nm)	$\Delta\lambda_{FWHM}/\lambda_0$ (%)	Science Purpose	Polarization	Channel	Coron.
465	10.0	continuum, Rayleigh	Pol.	Imager	HLC
565	10.0	continuum, Rayleigh	Pol.	Imager	HLC
835	6.0	CH_4 continuum	Pol.	Imager	SPC
885	5.6	CH_4 absorption	Pol.	Imager	SPC
660	18.0	CH_4 spectrum	Unpol.	IFS	SPC
770	18.0	CH_4 spectrum	Unpol.	IFS	SPC
890	18.0	CH_4 spectrum	Unpol.	IFS	SPC

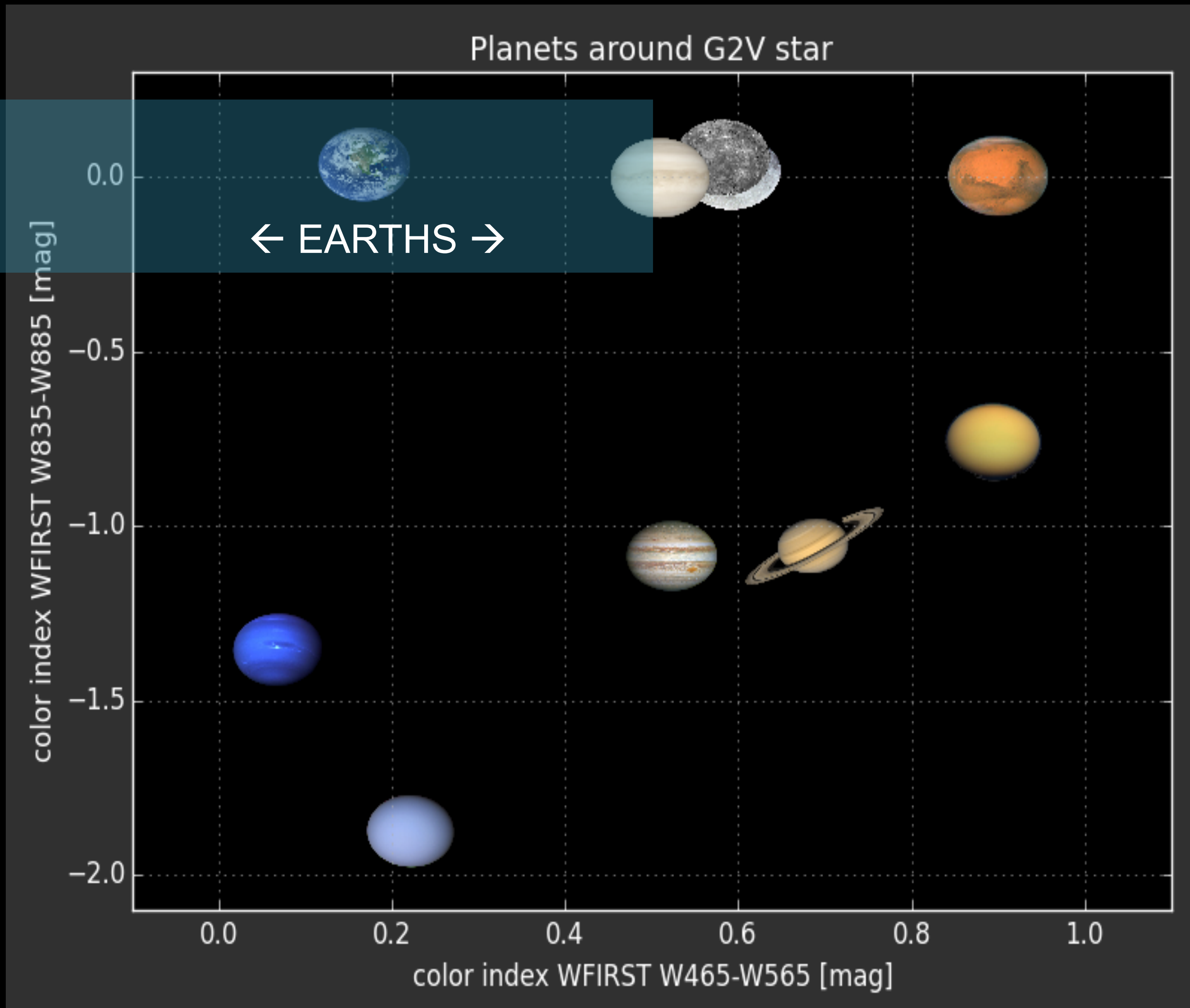
Planets Around the Sun: WFIRST Bands



Other (Super)Earth-Like Planets: WFIRST Bands



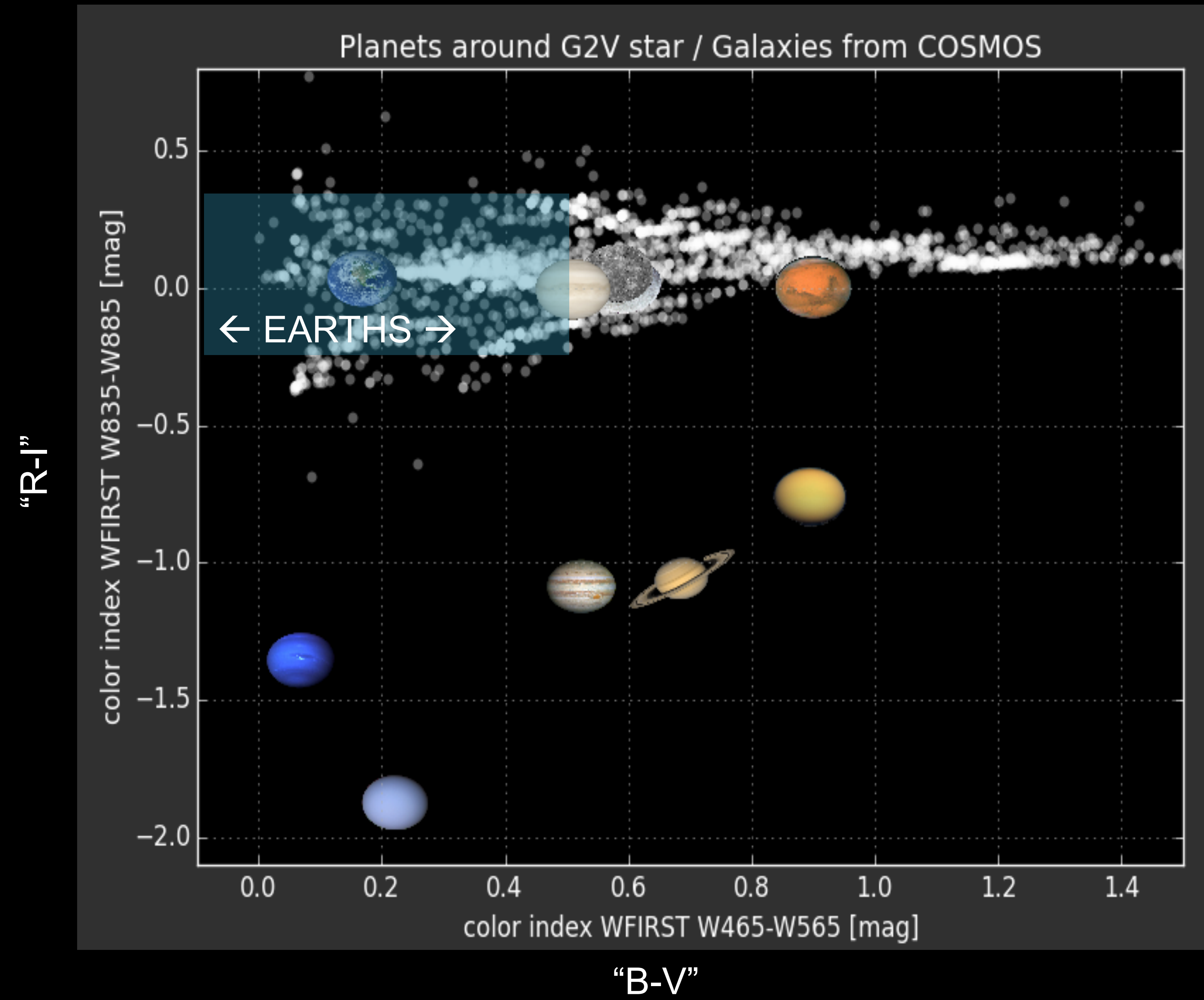
Planets Around the Sun: WFIRST Bands



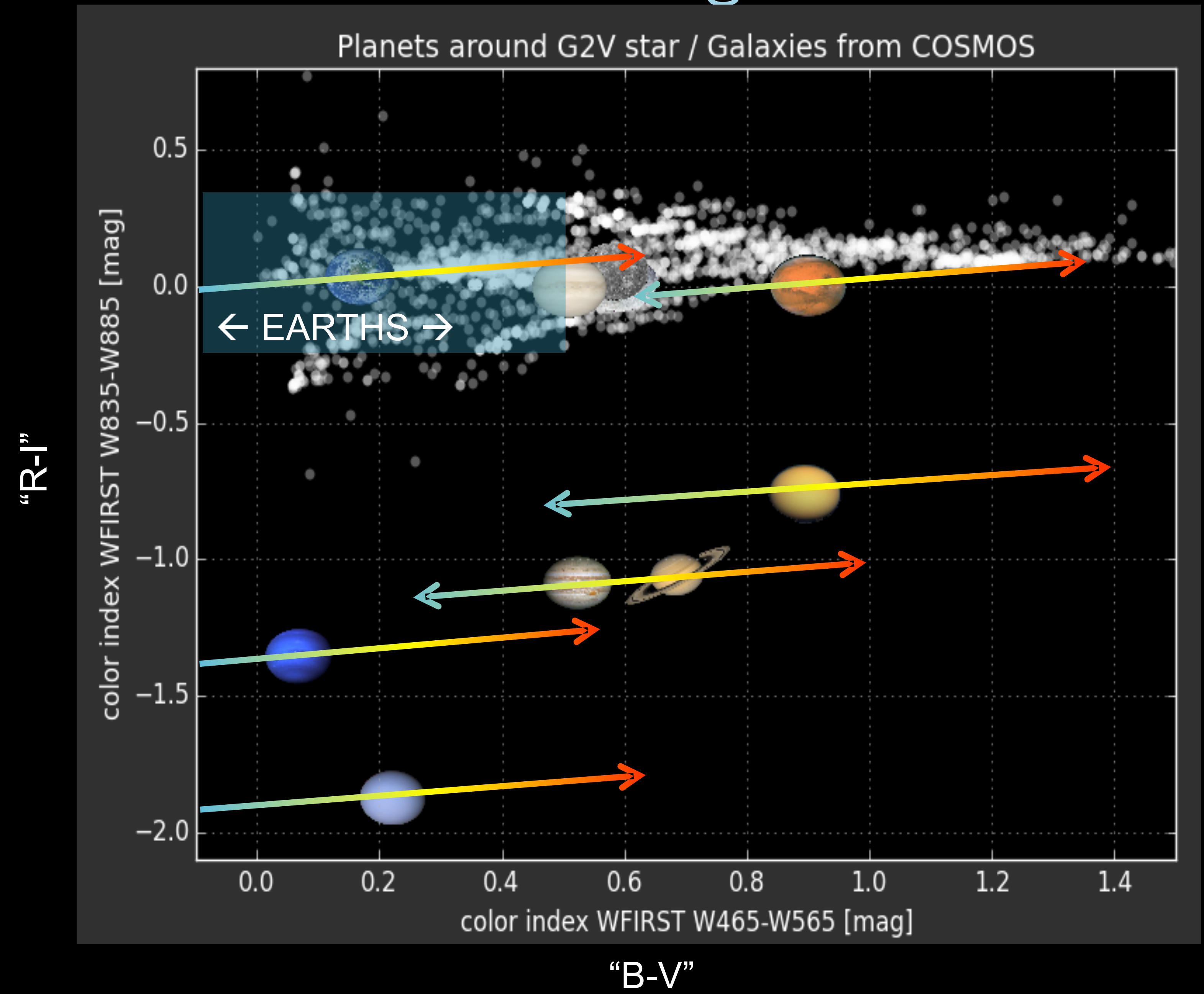
“R-I”

“B-V”

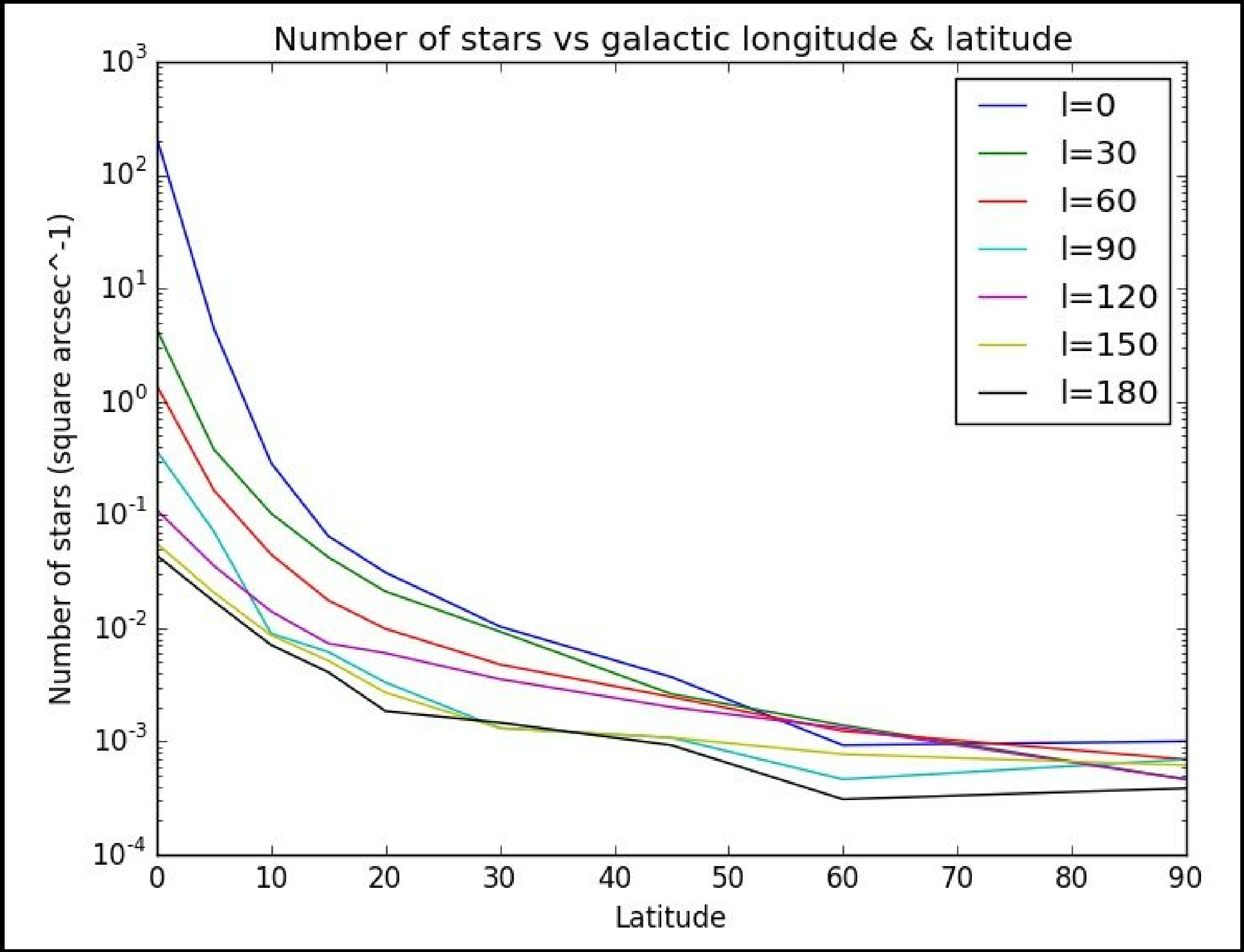
Planets Around the Sun: WFIRST Bands



Planets Around Other Targets: WFIRST Bands

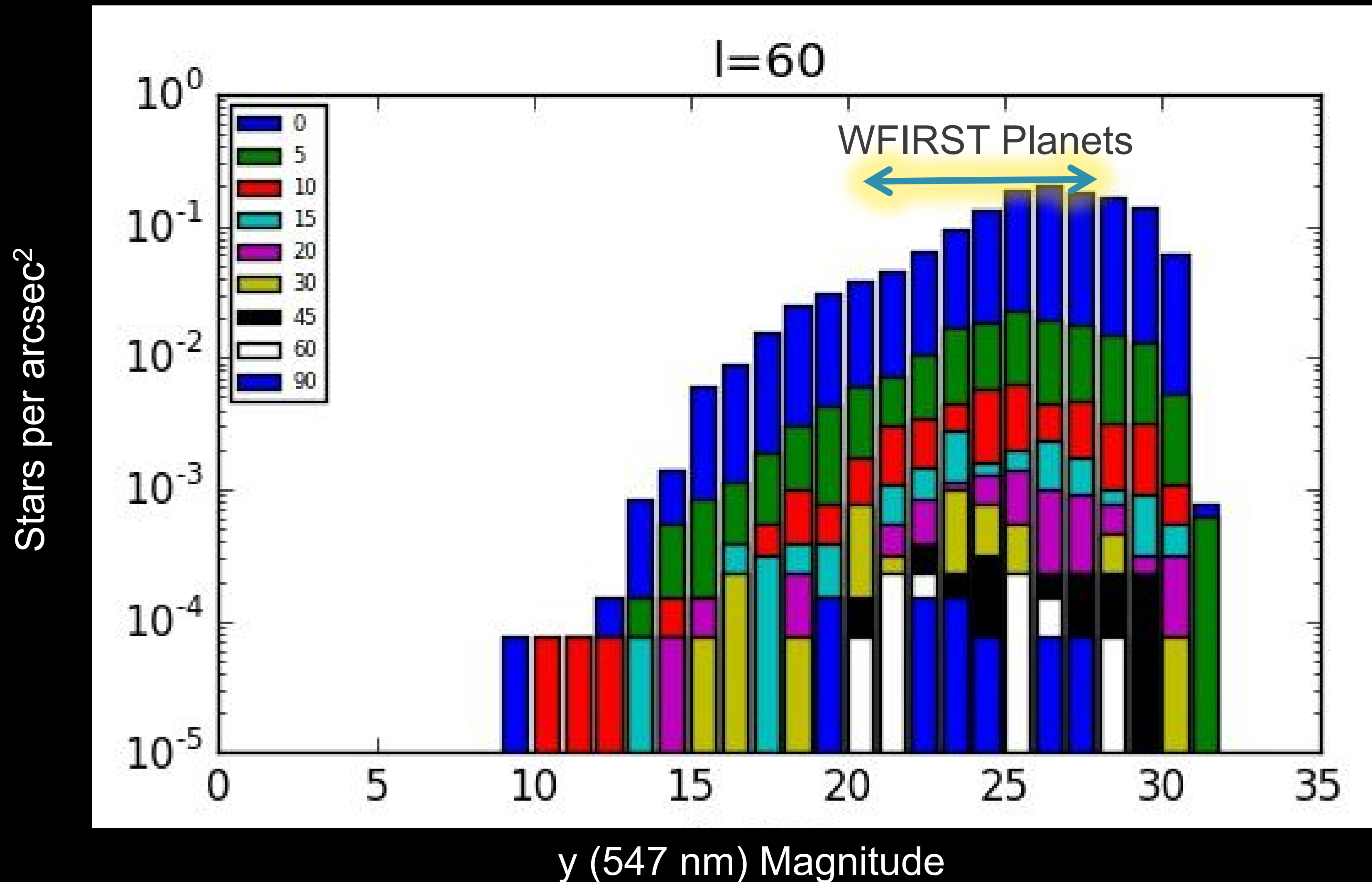


Background Stars



WFIRST FOV ~ 10 sq arcsec. Targets are unlikely to be plagued with background stars, though P~1 for lowest latitudes.

Background Stars



WFIRST FOV ~ 10 sq arcsec. Targets are unlikely to be plagued with background stars, though P~1 at planet magnitudes near the bulge.

Where We Stand With Planet Spectra

- Have generated crude Earth-like model spectra (desert, ocean, veg., snow) using cloud-free radiative transfer at a single angle
- Plan to use calibrated, spatially resolved spectra from Earth observing instruments to get more accurate surface reflectance
- Exploring tools for generating integrated spectra with polarization
  - Will use polarized, plane parallel RT model to generate pre-computed reflectance tables for various “Earth-like” conditions
  - Compute disk-integrated, polarized, spectral reflectance by integrating over spatially discretized Exo-Earths at a given phase angle
- Goal: RT implementation and verification: spring 2016; initial full polarized disk integrations: summer/fall 2016

Where We Stand With Planet Spectra

- Have begun building a small library of spectra including Solar System planets, models from Hu, Cahoy et al.
  - includes planets orbiting different kinds of stars at various separations, various C/O ratios
  - Goal is to make this publicly available in some organized way
- Plan to collaborate between teams (Lewis, Turnbull) to share models/agree on a subset for calculations
- Interest in obtaining spatially resolved spectra with MaNGA for Jupiter, Saturn, Venus

Where We Stand With Galaxies and Stars

- Have a code to calculate broadband magnitudes and colors
  - Next step will be to look at colors for Cahoy, Hu planets
- Will build a GUI tool that will allow users to upload spectra, bandpasses, or use ours
- Probability of finding background sources in the field:
  - Galaxies: High probability, > 50% for most targets down to contrast limit
  - Stars: Low probability, <10% for all targets down to contrast limit
- Will explore fastest PM follow-up times for scheduling codes
- Currently waiting on ODI observations with WIYN, HLA program in hopes of deep imaging along future PM paths

Where We Stand With The Targets

- Most targets have "bright" companions and/or high probability of off-axis background stars - Need off-axis response to estimate background light and potential impact on exposure time, planet harvest
- We find that most targets have physical companions – consider dynamics?
- Currently logging stray light, background worries for all targets
- Wish List: JHK for high priority targets (all of which are saturated in 2MASS) in order to accurately determine luminosities
  - this could be done in one year with minimal time on a small telescope north and south - need a near-IR camera
- Plan to collaborate with Savranksy team on database, starting with known RVs